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REVIEW ARTICLE

Major food safety episodes in Taiwan: Implications for the necessity of international collaboration on safety assessment and management

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Abstract The major food safety episodes that occurred in Taiwan during the past decade are briefly reviewed in this paper. Among the nine major episodes surveyed, with the exception of a U.S. beef (associated with Creutzfeldt–Jakob disease)-related incident, all the others were associated with chemical toxicants. The general public, which has a layperson attitude of zero tolerance toward food safety, may panic over these food-safety-associated incidents. However, the health effects and impacts of most incidents, with the exception of the melamine incident, were essentially not fully evaluated. The mass media play an important role in determining whether a food safety concern becomes a major incident. A well-coordinated and harmonized system for domestic and international collaboration to set up standards and regulations is critical, as observed in the incidents of pork with ractopamine, Chinese hairy crab with nitrofuran antibiotics, and U.S. wheat with malathion. In the future, it can be anticipated that food safety issues will draw more attention from the general public. For unknown new toxicants or illicit adulteration of food, the establishment of a more proactive safety assessment system to monitor potential threats and provide real-time information exchange is imperative.

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Introduction

Although food bears the presumption of safety, and the ultimate goal of the food industry and national policy-makers is to ensure that all food should be "safe and wholesome," complete freedom from risk has not yet been at hand [1,2]. In fact, along with the more and more globalized food trade, food safety has become one of our major concerns. For example, two recent issues of illicit adulteration of food, the 2008 melamine incident and the 2011 plasticizer incident, not only caused unwanted health effects but also resulted in tremendous social and economic costs [3—6]. Apart from illicit adulteration, food safety issues can also arise from a variety of causes, such as food allergy, anaphylactoid reaction, food—drug interactions and metabolic food reactions [1].

In Taiwan, as in many other countries, major food safety incidents have occurred during the past decade. Reviewing the causes of these incidents will not only provide us with clues to understand the risk factors that contributed to their occurrences but will also prevent us from experiencing similar situations in the future. As these incidents have not been systematically reviewed previously, the major food safety incidents that occurred in Taiwan in the past decade are therefore scrutinized in this paper and their causes and effects are discussed.

Definition of a major food safety incident

In this paper, a major food safety incident is defined as a food-safety—related issue that was reported by Taiwan's major press media, such as *Apple Daily, China Times, United Daily*, and *Liberty Times*, for more than 1 week, thereby drew the attention of the general public and had a substantial impact on society. Such major food safety incidents are responded to by the incumbent governmental agencies, with announcements of decision-making and/or action measures. The major food safety incidents were identified and analyzed according to their chemical and toxicologic characteristics, health effects, and social impacts, as well as possible solutions to the problems.

Occurrence and development of major food safety episodes in Taiwan

The major food safety episodes that occurred in Taiwan in the past decade are summarized in Table 1 [6—27]. Among the nine major food safety incidents, the food involved can be classified into five categories: (1) aquaculture products: grouper fish, trout, and Chinese hairy crab (three incidents); (2) farmed cattle meat: beef and pork (two incidents); (3) milk products and beverages (two incidents); (4) crop: wheat (one incident); and (5) fried oil (one incident). In most cases, the jurisdiction of food safety issues falls into the responsibility of more than one incumbent government agency in Taiwan. For instance, both the Department of Health and the Council of Agriculture are the gatekeepers of food safety in Categories (1), (2) and (4). If the regulations and standards of one agency are not in harmony with those of another agency, the situation may become chaotic. Related to the case of the incident of U.S. pork with ractopamine, the Department of Health intended to set up a maximum ractopamine residue level in pork in August 2007, only to find that the Council of Agriculture had banned the use of ractopamine as a feed additive in October 2006.

With respect to the classification of toxicants in these episodes, only one (the U.S. beef incident) was caused by a biologic agent (prion). The other eight incidents were all associated with chemical toxicants, which included malachite green and nitrofuran antibiotics (illicit additives used for antibacterial purposes, three cases), melamine and plasticizer (illicit adulteration, two cases), malathion and ractopamine (legal with residue limits in the source country but illegal in Taiwan, two cases), and arsenic (a false alarm, one case). A few of the chemicals that caused the food safety incidents may be questioned in terms of their potential to result in a real health threat. Taking nitrofuran antibiotics as an example, people who consumed nitrofuran-contaminated Chinese hairy crabs or trout may be concerned with the liability of getting cancer. However, nitrofuran antibiotics (e.g., nitrofurantoin) are still used clinically as a medication for treating urinary tract infection in humans. If large doses of nitrofuran antibiotics are not a concern with respect to patients developing cancers, then it is debatable whether trace amounts of nitrofuran antibiotics in Chinese hairy crabs or trout would cause cancers [28].

One should also be reminded that mass communication media play an important role in deciding whether a food safety incident is regarded as a major or significant issue. The fried oil with arsenic incident is a good example. It is now known that the fried oil, after confirmation testing, was found not to contain an excessive concentration of arsenic. Although it is always in the spirit of news media to report news with exclusivity and rapidity, truth seeking should also be one of the core values when pursuing breaking news.

Effects and impacts of major food safety episodes

The effects and impacts of these food safety episodes are also depicted in Table 1. With the exception of the poisonous milk (melamine) incident, the health effects and impacts of most incidents are yet to be evaluated, although people in Taiwan have already become panicky. The melamine incident represents one of the largest deliberate food adulteration events [3,4]. It has been shown that the incident affected about 300,000 Chinese infants and young children and caused six deaths. The tragedy also indicated that food safety incidents should be managed internationally, and as early as possible. Worldwide collaboration between food safety authorities is needed so that information exchange and tracking and recalling of affected products can be efficiently executed to ensure food safety [29]. A similar situation was the plasticizer incident, which was also a case of illicit adulteration and depended on international collaboration for information exchange, tracking and recalling of affected products to lessen the health effects and impacts [6]. However, as exposure to

Table 1 Major food safety episodes in Taiwan.

Incident	Main hazard involved	Occurrence and Development of the Incident	Effects and Impacts
U.S. beef	Creutzfeldt—Jakob disease (CJD), a prion-related disease.	Imports of U.S. beef were banned when the mad cow disease (bovine spongiform encephalopathy), a variant form of human CJD, was reported in the U.S. in December 2003 [7]. The imports, conditionally reopened in April 2005[8], were soon banned again in July 2005 but resumed conditionally in January 2006 [9]. The regulations regarding the import of U.S. beef and derived products were amended in 2009 [10].	The level of beef safety became a worldwide concern. The safety level of beef in Taiwan was downgraded to those in the United States and Canada [11]. The general public, by the influence of mass media, panicked over the possibility of contracting CJD if they consumed U.S. beef. In January 2010, lawmakers, reflecting the public concern that Taiwanese officials lacked sufficient protective measures, voted to ban the American ground beef and offal [12].
Grouper fish with malachite green	Malachite green, a carcinogenic anti-bacterial agent	On September 1, 2005, Hong Kong media reported that grouper fish from Taiwan was found to contain reducing type of malachite green [13]. In response, the Taiwan Fish farmers clarified the presence of residual amounts of reducing-type malachite green in the grouper fish was not a status quo [14].	The results aroused the public's concerns. The Council of Agriculture launched the "Good Aquaculture Practices" and "Food Traceability System."
Chinese hairy crab	Nitrofuran, a carcinogenic antibiotic	On October 18, 2006, many press media reported that Chinese hairy crabs imported from China contained carcinogenic nitrofuran antibiotics. The Department of Health (DOH) immediately took action to ban the crabs that were carrying in by tourists from China [15,16].	The DOH reinforced control measures but most imported Chinese hairy crabs had been sold and consumed by the people. The general public had the jitters over possible carcinogenicity after consumption of the crabs. Under the pressure of lawmakers, the Director of Food Sanitation, DOH, was forced to step down to ease the anger and panic of general public [17].
Poisonous trout	Nitrofuran, a carcinogenic antibiotic	In September 2006, nitrofuran antibiotics were identified from farmed trout. However, in contrast to the Chinese hairy crab incident, the nitrofuran-contaminated trout was not substantially reported.	In September 2007, nitrofuran was identified again from farmed trout [18].
U.S. wheat with malathion	Malathion, a pesticide	Residual malathion was identified by the Department of Health in July 2007 from the samples of 7662 tons of wheat that were imported from the United States [19]. Two batches of wheat were found with 0.64 ppm and 0.3 ppm of malathion, respectively. The regulation in Taiwan did not allow the presence of malathion in wheat. The two batches were therefore withheld in customs.	As a result, the price of wheat and its derived products, flour and bread, soared. (Trace amounts of Malathion were allowed in wheat by the WHO and the United States with limits of 0.5 and 8 ppm, respectively) [20]. In August 2007, the Department of Health revised the regulation to allow the presence of residual amount of malathion (0.5 ppm) in the wheat. The two batches of detained wheat in customs were released afterwards. [21]

Pork with ractopamine	Ractopamine	In July 2007, pork imported from the U.S. was found to contain ractopamine, which should not be detected in the pork according to Taiwan's regulation. However, it was also found that 7352 tons of U.S. pork that were previously shipped into Taiwan did not perform ractopamine testing from October 2006 to June 2007. On August 15, 2007, the Department of Health intended to revise the Regulation for the Residue Limits of Animal Drugs so that residual ractopamine could be tolerated in the pork. But it was found that ractopamine had been banned for use as an animal drug by the Council of Agriculture on October 11, 2006 [22].	The acceptable daily intake of ractopamine enacted by the FAO/WHO was 1 mg/kg [23]. Ractopamine was used as a feed additive in the United States and Canada. The Executive Yuan then intended to revise the regulation that would allow the presence of residual ractopamine for imported pork while maintaining zero tolerance for domestic pork. Being unfairly treated, the farmers took to street to protest the policy. The Executive Yuan reversed the decision immediately.
Poisonous milk (melamine)	Melamine	On September 12, 2008, China officials confirmed in a press conference that melamine-adulterated San-Lu milk powder had been shipped to Taiwan as a raw material in food. On September 18, 2008, Taiwan DOH announced that the distribution and sale of all milk-containing products from China were banned. On September 24, the limit of melamine in milk-containing food was set at 2.5 ppm but the decision was immediately reversed to allow non-detection of residual melamine in the food [24].	Melamine was illicitly adulterated as a forgery of high protein content. The flip-flop of melamine standards in milk set by the DOH upset the public and led to the step-down of the Health Minister. The Taiwan Food and Drug Administration (TFDA) was accordingly established on January 1, 2010 [25].
Fried oil with arsenic	Arsenic, a human carcinogen	On July 7, 2009, fried oils used by some fast-food restaurants were found to contain excessive arsenic by the Health Bureau of Taipei County [26].	However, on July 9, 2009, the DOH announced the arsenic contents of all sampled oils met the national standard after confirmation tests. The credibility of government tests on arsenic was tarnished [27].
Plasticizer	DEHP (di-(2-ethylhexyl) phthalate) and other plasticizers, environmental hormones that may affect sex organ development and cause cancers.	On May 23, 2011, all major news media reported the incident, which was actually detected 2 months earlier from a batch of probiotics raw material with a high concentration (600 ppm) of DEHP. Two upstream providers were identified for the deeds of illicit adulteration. It was soon found out that nearly all milk-associated food products were contaminated. The public panicked over the consumption [6].	As of July 20, 2011, 49,652 companies and stores were inspected by TFDA and 29,337 food items were pulled off the selves. Among these items, 1527.8 tons were confiscated and destroyed. The exposure to DEHP in Taiwan may have lasted for a long time. Long-term health effects remain to be observed [6].

Table 2 Management standards and characteristics related with the major food safety episodes in Taiwan.

Incident	Management Standards	Management Characteristics
U.S. beef (prion)	The Department of Health (DOH) announced on October 23, 2009, that import restrictions on US beef-with-bone products were being relaxed. Under the new policy, beef-with-bone, ground beef and offal that have not been contaminated with "specific risk materials" would be allowed to enter Taiwan, while other cattle parts, such as brains, skulls, eyes and spinal nerve from cattle over 30 months of age would remain on the banned list [10]. In January 2010, the Legislative Yuan voted to ban the U.S. ground beef and offal [12].	1.Multinational food trade. 2. Lack of routine analytical methods for prion inspection. 3. Risk assessment model and mechanism have not been established.
Grouper fish with malachite green	Malachite green is a carcinogen for animals and has been banned worldwide.	Multinational food trade.
Chinese hairy crab	The Council of Agriculture (COA) had banned the use of nitrofuran in animals since June 1, 2004. But the DOH did not implement the inspection until October 2006.	1. The authorities responsible for the management were not well coordinated. 2. Harmonization with international standards is needed. 3. The reason to ban the import from China was not verified: carcinogenicity or a banned drug?
Poisonous trout	In 2006, when the hairy crab imported from China was banned, farmed trout in Taiwan was also found to contain nitrofuran antibiotics at the same time. However, the poisonous trout was not immediately managed. Later the farmed trout was inspected again and the problem was revealed. The COA and the DOH criticized each other for being unable to take responsibility.	1. The authorities responsible for the management were not well coordinated. 2. The reason to ban the import from China was not verified: carcinogenicity or a banned drug?
U.S. wheat with malathion	1. The recommended maximum limit for malathion residue in wheat is 0.5 ppm (WHO) and 8 ppm (US) [20]. 2. Although there are residue limits for malathion in fruits and vegetables, but no standard had been set for wheat in Taiwan. The DOH then set a residue limit of 0.5 ppm on August 2007, but revised to 1.5 ppm on June 2009.	1. Multinational food trade 2. Lack of standards for regulation
Pork with ractopamine	The Joint FAO/WHO Expert Committee has set the acceptable daily intake (ADI) of ractopamine in 2006 [23]. Ractopamine can be added in feed in the United States and Canada.	1.Multinational food trade 2. The authorities responsible for the management were not well coordinated.
Poisonous milk (melamine)	1. Melamine is not a legal additive. 2. However, melamine products are ubiquitous and residual amounts could be present in the food.	1.Multinational food trade 2. Lack of routine analytical methods for inspection.
Fried oil with arsenic	The regulation allows a residue limit of arsenic in edible oil (lower than 0.1 ppm).	The test result was not reconfirmed in the local health agency before release.
Plasticizer	Plasticizer(s) is not a legal additive.	1.Multinational food trade. 2. Lack of routine analytical methods for inspection. 3. Risk assessment model and mechanism have not been established.

plasticizers is a long-term and high-dose phenomenon [30], an assessment of their health effects is urgently demanded. Furthermore, safety assessment and management of a few other incidents, such as the U.S. wheat with malathion and pork with ractopamine incidents, could not be executed because international standards have not been harmonized and a consensus has not been reached. A summary of the Management Standards and Characteristics related to the Major Food Safety Episodes in Taiwan is shown in Table 2 [10,12,20,23]. The main factors that contributed to the management characteristics of these incidents included: (1) multinational food trade; (2) lack of routine analytical methods for inspection; (3) a risk assessment model and mechanism have not been established; and (4) the authorities responsible for the management were not well-coordinated.

Another important issue is the perception of the general public of food safety. On one hand, it is understandable that most laypersons would have a notion of zero tolerance for any toxicant in food, and would panic should any toxicant be detected in food. This was especially true in the incidents of Chinese hairy crab with nitrofuran antibiotics, pork with ractopamine, and fried oil with arsenic. On the other hand, the zero tolerance policy for a specific toxicant in food may simply be due to lack of a national standard for a toxicant residue. For example, residues of pesticides are allowed to be present in vegetables or fruits according to Taiwan's regulations (Table 2). However, the limit for malathion residue in wheat was not established until the incident of U.S. wheat with malathion occurred. It would be difficult to assess the safety of trace amounts of toxicants in food without a national standard. Apparently, thorough scrutiny of food-safety-related regulations is as important as an educational program related to food safety for the general public. Such scrutiny is imperative in order to gather more international standards for reference, and demands further international collaboration and harmonization.

Conclusion and future trend

Along with the boom in international food trade, the issue of food safety has also become a global concern. In the past decade, Taiwan has experienced many major food-safety-related episodes, from which some lessons can be learned. These lessons are summed up as follows:

1. Although the scale of a food-safety-associated episode depends on the toxicologic nature of the toxicant and the exposure dose and dose rate, one should also keep in mind that the mass media play an important role in this regard. To prevent an incident from being exaggerated or distorted (as in the cases of fried oil with arsenic and Chinese hairy crabs with nitrofuran antibiotics), comprehensive information on the risks associated with a food safety incident is indispensable.
2. A well-coordinated and harmonized system for domestic and international collaboration on the setting up of standards and regulations is critical, as observed in the cases of pork with ractopamine, Chinese hairy crab, and U.S. wheat with malathion.
3. Proper food safety assessment and management demand thorough international collaboration to ensure transparent information exchange and traceability of affected products, as experienced in the cases of U.S. beef, poisonous milk (melamine) and plasticizers.

In the future, it can be anticipated that food safety issues will draw more attention from the general public. In Taiwan, to enhance food safety and prevent us from exposure to unwanted risks in food, a food safety control system that includes good hygienic practice and hazard analysis and critical control points has been implemented [31]. However, for unknown new compounds and illicit adulterations that cannot be detected through regular testing or inspection, a more proactive safety assessment system that includes international collaboration to assess potential new threats in food flow and real-time information exchange should be established as soon as possible.

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